PROTECTION SISTEMS OF THE TITLTING MECHANISMS AT THE ROLLING TRAINS

Lect. Eng. MIKLOS Imre Zsolt, Dr. es Sc.
"POLITEHNICA" UNIVERSITY - TIMIŞOARA,
FACULTY OF ENGINEERING - HUNEDOARA
MECHANICAL DEPARTMENT

Lect. Eng. CIOATĂ Vasile George, Dr. es Sc.
"POLITEHNICA" UNIVERSITY - TIMIŞOARA,
FACULTY OF ENGINEERING - HUNEDOARA
MECHANICAL DEPARTMENT

Prof. Eng. MIKLOS Imre, Dr. es Sc.
"POLITEHNICA" UNIVERSITY - TIMIŞOARA,
FACULTY OF ENGINEERING - HUNEDOARA
MECHANICAL DEPARTMENT

Lect. Eng. KISS Imre, Dr. es Sc.
"POLITEHNICA" UNIVERSITY - TIMIŞOARA,
FACULTY OF ENGINEERING - HUNEDOARA
METALLURGICAL DEPARTMENT

ABSTRACT

To the tilting mechanisms with hook from the rolling trains because of stuck of the hook in the way with rolls, appear additional loads in the tilting mechanisms elements, who can lead to destruction. For the protection of the mechanism, the connecting rod is fitted with a safety bolt, which shall tear through destruction in the moment of the additional load. The present work proposes the substitution of the bolt of destruction with a device, of type system of index, who give in the moment of the additional load, and he shall come back in the natural position to next cinematic cycle of the mechanism in the condition of ending the additional load, respectively the design and the experimental study in conditions of exploitation for different variants of the device.

KEYWORDS

rolling trains, tilting mechanisms, experimental study, processing results

1. INTRODUCTION

The paper presents the study of the tilting mechanism with hook, from the rolling train blooming 1000. To this mechanism, because of an wrong operation, it can happened, on one side, when the hooks are going down, they jabbed in the bloom, and at the other side when the hooks are going up, they can hung on the way with rolls of rolling train. This thing can bring destruction of the component elements by reason of additional load.

In the case of the tilting mechanism from the blooming 1000 mm, the main connecting rod is fitted with a section of minimum resistance, materialized with two safety bolts, which is brake up in the moment of the appearance of the additional load. The connecting rod's cross-section is presented in FIGURE 1.

The protection of the tilting mechanism with safety bolts is convenient at the first sight, only that she presents some disadvantages. Thus, in the moment of bolt break, by the reason of accidental additional loads, must interrupt the process of lamination on period time, in which time the broken bolt is taking and put another new one. This operation is difficult, due to the difficult intake to the section with bolts.

The object of this paper is a protective solution of the tilting mechanism from the rolling trains, lock limiter automatic force type. For design this, is necessary to know the value of the force from the connecting rod of the tilting mechanism. The blooms tilting mechanism work with shocks and therefore, the state of efforts from his elements can't be determinate just when the dynamic coefficient is known very well. To have a real situation, is accepted the experimental method (with tensometrical stamps).

After the measurements is obtained the maximum values of the force from the connecting rod of the mechanism in the next conditions:

- 97800 N, to working in empty;
- 475000 N, to working in charge;
- 1350000 N, to break of the bolts.

2. DESCRIPTION AND WORKING OF THE LOCK LIMITER AUTOMATIC FORCE

The authors proposed two variants of lock limiter automatic force, with tapered blocking bodies and with balls. The schematic sketches of the two variants are presented in FIGURE 2 (a, b).

The press force Q from the compression spring (4), is calibrated depending on maximum force of regime from connecting rod. In the moment when force **F** from connecting rod exceeded a certain pre-value, the blocking bodies (3) will be pushed in outside of the transversal seats, compressing the springs until these gets away from the two tapered bores. After additional load is ending, the compression springs shall push backward the blocking bodies in the tapered bores from connecting rod. Thus the mid-section of the connecting rod is displaced by the exterior one, permitting the end of solicitation, achieving thus the enclosing the lock limiter automatic force to the next kinematic cycle.

Taking in consideration that the critical force from connecting rod (the spring press force) are very big and because the space where the spring is placed is limited (for a little deformation), is recommended compression ring-shaped type springs to use, who satisfy the conditions below.

3. CALCULATION AND DESIGN OF LOCK LIMITER AUTOMATIC OF FORCE

a) For the case of the tapered blocking bodies is noted with F the force from connecting rod where the lock is breaking up, lock presented in FIGURE 2. The force is in equal mode distributed on each pairs of blocking bodies. On each blocking bodies, will be act the half from the critical force, F/2. The scheme of load of a blocking body is presented in FIGURE 3.

With the notations from FIGURE 3 between the distributed force, F/2 and force P who pushes the blocking body in the tapered bore, the following relation can be writing:

$$P = \frac{F}{4 \cdot (\sin\alpha + \mu \cdot \cos\alpha)} \tag{1}$$

Forces who acts on the blocking bodies (FIGURE 4) will be: P, respectively μP, spring press force Q and N_1, N_2 (the reactions of slideway) respectively F_1 and F_2 the frictional forces in the slideway. From the equilibrium condition of the forces, results the relation of the force P depending on Q and the geometrical sizes of the tapered blocking body.

$$P = \frac{Q}{\left[\cos\alpha - \mu \cdot \sin\alpha\left(1 + \frac{2 \cdot b}{l} - \frac{\mu \cdot a}{l}\right)\right]} \tag{2}$$

Next, the problem is to choose the optimal value of the angle α of tapered body of lock, respectively to determinate the limit value to avoiding the stuck phenomenon in the tapered bore of the connecting rod, in working conditions.

The stacking of the blocking body in the tapered bore from connecting rod is produced when the denominator of the relation (2) is null, respectively force P tend to infinite. Taking count of these specifications and the fact that the angle α can't have negative values, the domain in which can take values the angle α is:

$$0 < \alpha < \operatorname{arctg} \frac{1}{\mu \cdot \left(1 + \frac{2 \cdot b}{l} - \frac{\mu \cdot a}{l}\right)} \tag{3}$$

From the relations (1) and (2) is determined the value of the spring press force, Q:

$$Q = \frac{F \cdot \left[\cos\alpha - \mu \cdot \left(1 + \frac{2 \cdot b}{l} - \frac{\mu \cdot a}{l}\right) \cdot \sin\alpha\right]}{4(\sin\alpha + \mu \cdot \cos\alpha)} \tag{4}$$

or $Q = K \cdot F$

$$K = \frac{\cos\alpha - \mu \cdot \left(1 + \frac{2 \cdot b}{l} - \frac{\mu \cdot a}{l}\right) \cdot \sin\alpha}{4 \cdot (\sin\alpha + \mu \cdot \cos\alpha)} \tag{5}$$

For $F = F_{max} \Rightarrow Q = Q_{max}$

The lock limiter automatic force was modeled in the Mechanical Desktop program, the rendered image of this is presented in FIGURE 5.

The relations (1)...(5) were solved with a calculation program, who permits to know the maximum values of angle α, α_{max}, where appear the stuck of the blocking body in connecting rod, and Q spring press force, for different values of friction coefficient μ (different pairs of materials), respectively the geometrical sizes of the tapered blocking body.

Keeping the geometric sizes constant, for different values of friction coefficient between the tapered blocking body material and the connecting rod material, are obtained differently limits values for the angle of the blocking body.

For the real case analyzed of the tilting mechanism, admitting $\mu = 0.15$, will be result the maximum angle where appear the danger of stacking lock:

$$\alpha_{max} = 78.68 \text{ [degree]}$$

For the covering the estimation who was made in calculations, this value is reduced with a safety factor 1.3, resulting:

$$\alpha_{lim} = \frac{78,68}{1,3} = 60[\text{degree}]$$

b) For the case of limiter lock of force with balls (FIGURE 2) it can considered the same conditions of load as in case of the tapered blocking bodies. The calculation scheme is presented in FIGURE 6.

From the condition of equilibrium is determined the spring press force:

$$F_{larc} = \frac{F_{max}}{2}\left[\left(1-\mu_0^2\right)\cdot tg\alpha - 2\cdot\mu_0\right] \tag{6}$$

4. EXPERIMENTAL TRIALS

The experimental trials were made for the variant case with tapered blocking bodies. Because the main connecting rod of the tilting mechanism has big length (2480 mm), for the experimental trials, it was considered just a portion from connecting rod, respectively the portion, on which is assembled lock limiter automatic of force. Lock limiter automatic of force is presented in FIGURE 7. The experimental trials on lock limiter automatic of force with tapered blocking bodies has been made on the universal machine of tried to stretch and pressure, presented in FIGURE 8.

From the experimental trials results that the lock is broken on values between 50200 and 50750 daN of the force from connecting rod, near value of the one obtained by calculation (53010 daN).

The pairs of values *force – displacement of connecting rod*, read on measure equipment of the machine of tried was estimated through interpolation with Lagrange polynom.

The estimation with the Lagrange method of interpolation consists in determination a polynom of this form:

$$P_n(x) = L_0(x)\cdot y_0 + L_1(x)\cdot y_1 + ... + L_n(x)\cdot y_n \tag{7}$$

where: The coefficients $L_i(x)$ - polynoms of n degree named Lagrange polynoms. The value of n represents a number of pairs of values (x_0, y_0), (x_n, y_n), read on the measure equipment of the machine of tried to stretch and pressure.

The shape of Lagrange polynom is:

$$L_i(x) = \frac{(x-x_0)\cdot(x-x_1).....(x-x_{i-1})\cdot(x-x_{i+1}).....(x-x_n)}{(x_i-x_0)\cdot(x_i-x_1).....(x_i-x_{i-1})\cdot(x_i-x_{i+1}).....(x_i-x_n)} \quad (8)$$

To the final, the interpolation polynom have the following form:

$$P_n(x) = \sum_{i=0}^{n} a_i \cdot x^{n-1} = a_0 \cdot x^n + a_1 \cdot x^{n-1} + ... + a_{n-1} \cdot x + a_n \quad (9)$$

For the 76 read pairs of values (*force - displacement*), result a interpolation polynom of the 76 degree. The interpolation was made with a program write in Matlab, and the graphic representation of the estimation polynom is presented in FIGURE 9.

5. CONCLUSION

After the experimental trials the conclusion is that lock limiter automatic of force works correct, and he brakes up in to a value of force near to the one obtained through calculation.

The blocking bodies don't present deformation because of contact solicitation, respectively no element of wear. In these conditions the blocking bodies are still in good shape of working.

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FIGURES

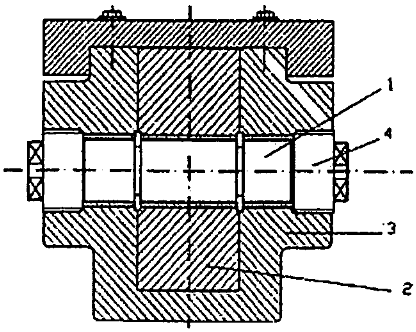


Figure 1.

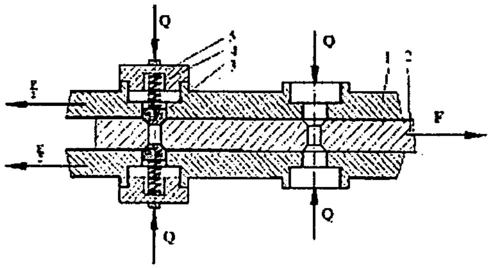
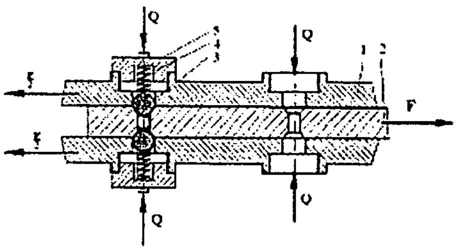


Figure 2/a



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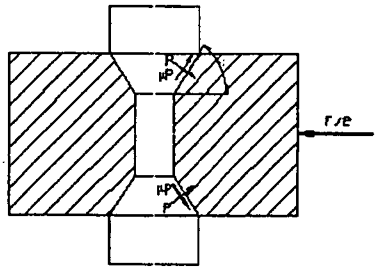

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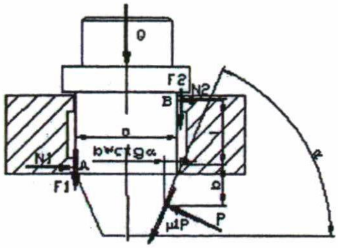

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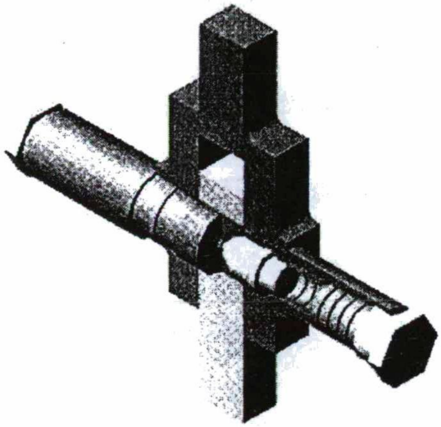

Figure 5/a

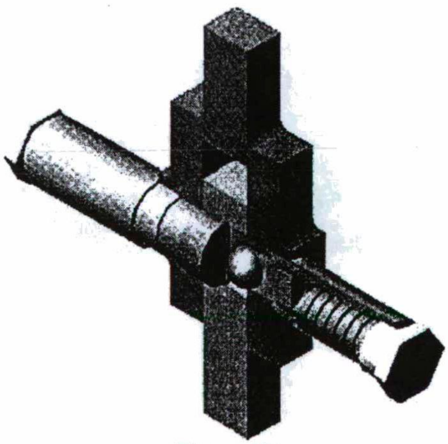

Figure 5/b

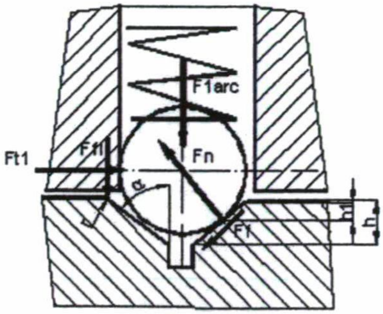

Figure 6.

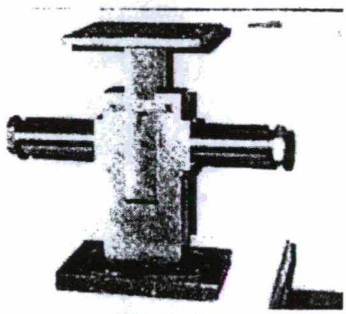

Figure 7.

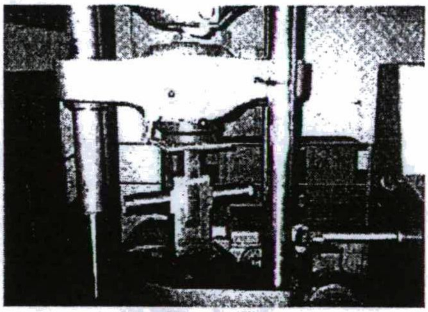

Figure 8.

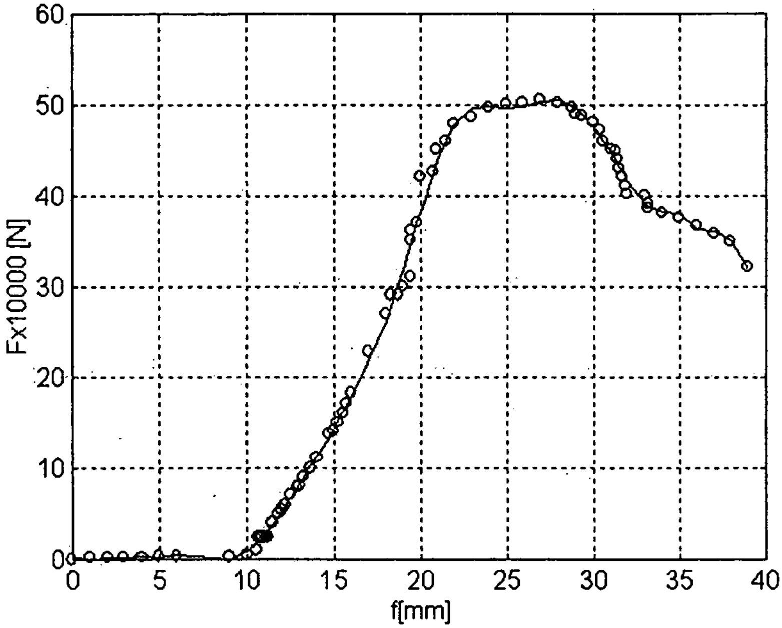

Figure 9.